CLAIMS

What is claimed is:

1. A method for processing data received from a communications channel comprising the computer-implemented steps of:

   receiving, from the communications channel, received data that is based upon both modulated data and noise, wherein the modulated data is the result of original data modulated onto one or more carriers;

   equalizing the received data to generate equalized data, wherein the equalizing is performed using an algorithm with a set of one or more coefficients selected based on noise power and an impulse response of the communications channel; and

   recovering an estimate of the original data by demodulating the equalized data.

2. The method as recited in Claim 1, wherein the set of one or more coefficients is selected to optimize an impulse response length of the communications channel to reduce interference.

3. The method as recited in Claim 2, wherein the interference includes inter-symbol interference.

4. The method as recited in Claim 2, wherein the interference includes inter-channel interference.

5. The method as recited in Claim 1, wherein the set of one or more coefficients is selected to reduce the noise power.

6. The method as recited in Claim 5, wherein the set of one or more coefficients is selected to minimize noise power.

7. The method as recited in Claim 1, wherein the set of one or more coefficients is selected to simultaneously optimize an impulse response length of the communications channel to reduce interference and reduce the noise power.

8. The method as recited in Claim 1, wherein a cyclic prefix is added to the modulated data and the set of one or more coefficients is selected to ensure that an impulse response of the communications channel and a device that performs the step of equalizing is less than a length of the cyclic prefix.

9. The method as recited in Claim 1, wherein the set of one or more coefficients is selected to reduce the noise power due to inter-symbol interference, inter-channel interference, and noise from one or more additional interference sources.

10. The method as recited in Claim 9, wherein the one or more additional interference sources includes at least one interference source selected from the group consisting of crosstalk, amplitude-modulated signals, and white Gaussian noise.

11. The method as recited in Claim 1, wherein the set of one or more coefficients are selected by minimizing a function of communications channel impulse response and noise power.

12. The method as recited in Claim 1, wherein the set of one or more coefficients are selected based on a noise power spectral density.

13. The method as recited in Claim 1, wherein the step of equalizing the received data includes processing the received data using a finite impulse response (FIR) filter.

14. The method as recited in Claim 13, wherein the received data is modulated using discrete multitone modulation and a set of one or more (FIR) coefficients for the FIR filter is selected to minimize noise power and optimize impulse response length of the communications channel to reduce interference.

15. The method as recited in Claim 1, wherein the communications channel is a twisted pair telephone line.

16. The method as recited in Claim 1, wherein the twisted pair telephone line uses a transmission protocol selected from the group consisting of Asymmetric Digital Subscriber Line (ADSL), G.Lite and Very High Bit Rate DSL (VDSL).

17. A method for determining coefficients for use in a filter to process data received from a communications channel comprising the computer-implemented steps of:
determining a communications channel transfer function based on the received data;
determining a noise power spectral density based on the received data;
determining a communications channel impulse response based on the communications channel transfer function;
determining a noise covariance based on the noise power spectral density; and
determining the coefficients based on the communications channel impulse response and the noise covariance.

18. The method as recited in Claim 17, wherein the step of determining the communications channel transfer function includes the computer-implemented steps of:
accumulating a plurality of symbol values based on the received data;
determining an average received symbol value based on the received data; and
determining the communications channel transfer function based on the plurality of symbol values and the average received symbol value.

19. The method as recited in Claim 17, wherein the step of determining the noise power spectral density includes the computer-implemented steps of:
measuring a plurality of symbol values based on the received data;
determining an average received symbol value based on the received data; and
determining the noise power spectral density based on the plurality of symbol values and the average received symbol value.

20. The method as recited in Claim 17, wherein the step of determining the communications channel impulse response includes the computer-implemented step of:
determining the communications channel impulse response based on an inverse fast Fourier transform (FFT) of the communications channel transfer function.

21. The method as recited in Claim 17, wherein the step of determining the noise covariance includes the computer-implemented step of:
determining the noise covariance based on an inverse fast Fourier transform (FFT) of the noise power spectral density.

22. The method as recited in Claim 17, wherein the step of determining the coefficients includes the computer-implemented steps of:
forming two matrices based on the communications channel impulse response and the noise covariance;
generating a quadratic expression based on the two matrices; and
minimizing the quadratic expression to determine the coefficients.

23. A computer-readable medium carrying one or more sequences of instructions for processing data received from a communications channel, wherein execution of the one or more sequences of instructions by one or more processors causes the one or more processors to perform the steps of:
receiving, from the communications channel, received data that is based upon both modulated data and noise, wherein the modulated data is the result of original data modulated onto one or more carriers;
equalizing the received data to generate equalized data, wherein the equalizing is performed using an algorithm with a set of one or more coefficients selected based on noise power and an impulse response of the communications channel; and
recovering an estimate of the original data by demodulating the equalized data.

24. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients is selected to optimize an impulse response length of the communications channel to reduce interference.

25. The computer-readable medium as recited in Claim 24, wherein the interference includes inter-symbol interference.

26. The computer-readable medium as recited in Claim 24, wherein the interference includes inter-channel interference.

27. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients is selected to reduce the noise power.

28. The computer-readable medium as recited in Claim 27, wherein the set of one or more coefficients is selected to minimize noise power.

29. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients is selected to simultaneously optimize an impulse response length of the communications channel to reduce interference and reduce the noise power.

30. The computer-readable medium as recited in Claim 23, wherein a cyclic prefix is added to the modulated data and the set of one or more coefficients is selected to ensure that an impulse response of the communications channel and a device that performs the step of equalizing is less than a length of the cyclic prefix.

31. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients is selected to reduce the noise power due to inter-symbol interference, inter-channel interference, and noise from one or more additional interference sources.

32. The computer-readable medium as recited in Claim 31, wherein the one or more additional interference sources includes at least one interference source selected from the group consisting of crosstalk, amplitude-modulated signals, and white Gaussian noise.

33. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients are selected by minimizing a function of communications channel impulse response and noise power.

34. The computer-readable medium as recited in Claim 23, wherein the set of one or more coefficients are selected based on a noise power spectral density.

35. The computer-readable medium as recited in Claim 23, wherein the instructions for equalizing the received data further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the step of processing the received data using a finite impulse response (FIR) filter.

36. The computer-readable medium as recited in Claim 35, wherein the received data is modulated using discrete multitone modulation and a set of one or more (FIR) coefficients for the FIR filter is selected to minimize noise power and optimize impulse response length of the communications channel to reduce interference.

37. The computer-readable medium as recited in Claim 23, wherein the communications channel is a twisted pair telephone line.

38. The computer-readable medium as recited in Claim 23, wherein the twisted pair telephone line uses a transmission protocol selected from the group consisting of Asymmetric Digital Subscriber Line (ADSL), G.Lite and Very High Bit Rate DSL (VDSL).

39. A computer-readable medium carrying one or more sequences of instructions for determining coefficients for use in a filter to process data received from a communications channel, wherein execution of the one or more sequences of instructions by one or more processors causes the one or more processors to perform the steps of:

determining a communications channel transfer function based on the received data;

determining a noise power spectral density based on the received data;

determining a communications channel impulse response based on the communications channel transfer function;

determining a noise covariance based on the noise power spectral density; and

determining the coefficients based on the communications channel impulse response and the noise covariance.

40. The computer-readable medium as recited in Claim 39, wherein the instructions for determining the communications channel transfer function further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the steps of:
accumulating a plurality of symbol values based on the received data;
determining an average received symbol value based on the received data; and
determining the communications channel transfer function based on the plurality of symbol values and the average received symbol value.

41. The computer-readable medium as recited in Claim 39, wherein the instructions for determining the noise power spectral density further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the steps of:
measuring a plurality of symbol values based on the received data;
determining an average received symbol value based on the received data; and
determining the noise power spectral density based on the plurality of symbol values and the average received symbol value.

42. The computer-readable medium as recited in Claim 39, wherein the instructions for determining the communications channel impulse response further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the step of:
determining the communications channel impulse response based on an inverse fast Fourier transform (FFT) of the communications channel transfer function.

43. The computer-readable medium as recited in Claim 39, wherein the instructions for determining the noise covariance further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the step of:
determining the noise covariance based on an inverse fast Fourier transform (FFT) of the noise power spectral density.

44. The computer-readable medium as recited in Claim 39, wherein the instructions for determining the coefficients further comprise instructions which, when executed by the one or more processors, cause the one or more processors to carry out the steps of:

forming two matrices based on the communications channel impulse response and the noise covariance;

generating a quadratic expression based on the two matrices; and

minimizing the quadratic expression to determine the coefficients.

45. An apparatus for processing data received from a communications channel comprising:

an equalizer configured to equalize received data from the communications channel and generate equalized data, wherein the received data is based upon both modulated data and noise, and the modulated data is the result of original data modulated onto one or more carriers, and wherein the equalizer is configured to use an algorithm with a set of one or more coefficients selected based on noise power and an impulse response of the communications channel; and

a demodulator configured to generate an estimate of the original data by demodulating the equalized data.

46. The apparatus as recited in Claim 45, wherein the set of one or more coefficients is selected to optimize an impulse response length of the communications channel to reduce interference.

47. The apparatus as recited in Claim 46, wherein the interference includes inter-symbol interference.

48. The apparatus as recited in Claim 46, wherein the interference includes inter-channel interference.

49. The apparatus as recited in Claim 45, wherein the set of one or more coefficients is selected to reduce the noise power.

50. The apparatus as recited in Claim 49, wherein the set of one or more coefficients is selected to minimize noise power.

51. The apparatus as recited in Claim 45, wherein the set of one or more coefficients is selected to simultaneously optimize an impulse response length of the communications channel to reduce interference and reduce the noise power.

52. The apparatus as recited in Claim 45, wherein a cyclic prefix is added to the modulated data and the set of one or more coefficients is selected to ensure that an impulse response of the communications channel and the equalizer is less than a length of the cyclic prefix.

53. The apparatus as recited in Claim 45, wherein the set of one or more coefficients is selected to reduce the noise power due to inter-symbol interference, inter-channel interference, and noise from one or more additional interference sources.

54. The apparatus as recited in Claim 53, wherein the one or more additional interference sources includes at least one interference source selected from the group consisting of crosstalk, amplitude-modulated signals, and white Gaussian noise.

55. The apparatus as recited in Claim 45, wherein the set of one or more coefficients are selected by minimizing a function of communications channel impulse response and noise power.

56. The apparatus as recited in Claim 45, wherein the set of one or more coefficients are selected based on a noise power spectral density.

57. The apparatus as recited in Claim 45, wherein the equalizer is configured to process the received data using a finite impulse response (FIR) filter.

58. The apparatus as recited in Claim 57, wherein the received data is modulated using discrete multitone modulation and a set of one or more (FIR) coefficients for the FIR filter is selected to minimize noise power and optimize impulse response length of the communications channel to reduce interference.

59. The apparatus as recited in Claim 45, wherein the communications channel is a twisted pair telephone line.

60. The apparatus as recited in Claim 45, wherein the twisted pair telephone line uses a transmission protocol selected from the group consisting of Asymmetric Digital Subscriber Line (ADSL), G.Lite and Very High Bit Rate DSL (VDSL).

61. An apparatus for determining coefficients for use in a filter to process data received from a communications channel comprising:

means for determining a communications channel transfer function based on the received data;

means for determining a noise power spectral density based on the received data;

means for determining a communications channel impulse response based on the communications channel transfer function;

means for determining a noise covariance based on the noise power spectral density; and

means for determining the coefficients based on the communications channel impulse response and the noise covariance.

62. The apparatus as recited in Claim 61, wherein the means for determining the communications channel transfer function includes:

means for accumulating a plurality of symbol values based on the received data;

means for determining an average received symbol value based on the received data; and

means for determining the communications channel transfer function based on the plurality of symbol values and the average received symbol value.

63. The apparatus as recited in Claim 61, wherein the means for determining the noise power spectral density includes:

means for measuring a plurality of symbol values based on the received data;

means for determining an average received symbol value based on the received data; and

means for determining the noise power spectral density based on the plurality of symbol values and the average received symbol value.

64. The apparatus as recited in Claim 61, wherein the means for determining the communications channel impulse response includes:

means for determining the communications channel impulse response based on an inverse fast Fourier transform (FFT) of the communications channel transfer function.

65. The apparatus as recited in Claim 61, wherein the means for determining the noise covariance includes:

means for determining the noise covariance based on an inverse fast Fourier transform (FFT) of the noise power spectral density.

66. The apparatus as recited in Claim 61, wherein the means for determining the coefficients includes:

means for forming two matrices based on the communications channel impulse response and the noise covariance;

means for generating a quadratic expression based on the two matrices; and

means for minimizing the quadratic expression to determine the coefficients.

67. A method for generating coefficient data comprising the computer-implemented step of generating coefficient data that represents a set of one or more coefficients that are selected based on noise power and an impulse response of a communications channel when the coefficients are used with an algorithm to equalize received data from the communications channel, wherein the received data is based upon both modulated data and noise and the modulated data is the result of original data modulated onto one or more carriers.

68. A computer-readable medium carrying coefficient data that represents a set of one or more coefficients that are selected based on noise power and an impulse response of a communications channel when the coefficients are used with an algorithm to equalize received data from the communications channel, wherein the received data is based upon both modulated data and noise and the modulated data is the result of original data modulated onto one or more carriers.

69. An apparatus for generating coefficient data comprising:

a storage medium for storing the coefficient data; and

a coefficient generator configured to generate the coefficient data, wherein the coefficient data represents a set of one or more coefficients that are selected based on noise power and an impulse response of a communications channel when the coefficients are used with an algorithm to equalize received data from the communications channel, wherein the received data is based upon both modulated data and noise and the modulated data is the result of original data modulated onto one or more carriers.